CLAIMS

What is claimed is:

1. A method for forming a refractory metal-intermetallic composite, the method comprising:

providing a first powder comprising a refractory metal suitable for forming a metal phase;

providing a second powder comprising a silicide precursor suitable for forming an intermetallic phase;

blending the first powder and the second powder to form a powder blend;

consolidating and mechanically deforming the powder blend at a first temperature; and

reacting the powder blend at a second temperature to form the metal phase and the intermetallic phase of the refractory metal-intermetallic composite, wherein the second temperature is higher than the first temperature.

2. The method of claim 1, wherein the first powder comprises at least one of niobium, titanium, and molybdenum.

3. The method of claim 1, wherein the first powder comprises niobium, titanium, and hafnium.

4. The method of claim 1, wherein the second powder comprises at least one of silicon, germanium, and boron.

5. The method of claim 1, wherein the second powder comprises silicon, chromium, and aluminum.

6. The method of claim 1, wherein the refractory metal-intermetallic composite comprises titanium, hafnium, silicon, chromium, and niobium.

7. The method of claim 1, wherein the refractory metal-intermetallic composite comprises between about 15 atomic percent and about 30 atomic percent titanium, between about 1 atomic percent and about 8 atomic percent hafnium, between about 5 atomic percent and about 25 atomic percent silicon, between about 1 atomic percent and about 14 atomic percent chromium, and a balance of niobium, based upon the total composition.

8. The method of claim 1, wherein the refractory metal-intermetallic composite comprises between about 15 atomic percent and about 30 atomic percent titanium, between about 1 atomic percent and about 8 atomic percent hafnium, up to about 10 atomic percent tantalum, between about 5 atomic percent and about 25 atomic percent silicon, up to about 6 atomic percent germanium, up to about 12 atomic percent boron, between about 1 atomic percent and about 14 atomic percent chromium, up to about 4 atomic percent iron, up to about 4 atomic percent aluminum, up to about 5 atomic percent tin, up to about 3 atomic percent tungsten, up to about 3 atomic percent molybdenum, and a balance of Niobium, based upon the total composition.

9. The method of claim 1, wherein the refractory metal-intermetallic composite comprises silicon, germanium, and boron, together comprising between about 5 atomic percent and about 25 atomic percent of the refractory metal-intermetallic composite, iron and chromium, together comprising between about 1 atomic percent and about 18 atomic percent of the refractory metal-intermetallic composite.

10. The method of claim 1, wherein consolidating the powder blend comprises consolidating the powder blend using a technique selected from the group consisting of cold isostatic pressing, hot isostatic pressing, hot pressing, explosive consolidation,

magnetic pulse consolidation, ram pre-extrusion consolidation, hot forging, hot swaging, and hot extrusion.

11. The method of claim 1, wherein mechanically deforming the powder blend comprises mechanically deforming the powder blend using a technique selected from the group consisting of cold extrusion, hot extrusion, cold forging, hot forging, cold rolling, hot rolling, cold swaging, and hot swaging.

12. The method of claim 1, wherein the first temperature is less than that required for a silicide reaction to begin.

13. The method of claim 1, wherein the first temperature is less than about 1,050 degrees C.

14. The method of claim 13, wherein the first temperature is maintained for a time of less than about 2 hours.

15. The method of claim 1, wherein the second temperature is greater than that required for a silicide reaction to be complete.

16. The method of claim 1, wherein the second temperature is greater than about 1,050 degrees C.

17. The method of claim 16, wherein the second temperature is maintained for a time of more than about 4 hours.

18. The method of claim 1, wherein the refractory metal-intermetallic composite has a graded composition.

19. The method of claim 1, further comprising disposing an environmentally-resistant coating on a surface of the refractory metal-intermetallic composite.

20. The method of claim 1, further comprising disposing a thermal barrier coating on a surface of the refractory metal intermetallic composite.

21. The method of claim 1, further comprising using high-energy ball milling to achieve a coating of the first powder comprising the refractory metal on the second powder comprising the silicide precursor.

22. A refractory metal-intermetallic composite manufactured by the method of claim 1.

23. A method for forming a refractory metal-intermetallic composite article, the method comprising:

providing a first powder comprising a refractory metal suitable for forming a metal phase;

providing a second powder comprising a silicide precursor suitable for forming an intermetallic phase;

blending the first powder and the second powder to form a powder blend;

consolidating and mechanically deforming the powder blend at a first temperature; and

reacting the powder blend at a second temperature to form the metal phase and the intermetallic phase of the refractory metal-intermetallic composite article, wherein the second temperature is higher than the first temperature.

24. The method of claim 23, wherein the first powder comprises at least one of niobium, titanium, and molybdenum.

25. The method of claim 23, wherein the first powder comprises niobium, titanium, and hafnium.

26. The method of claim 23, wherein the second powder comprises at least one of silicon, germanium, and boron.

27. The method of claim 23, wherein the second powder comprises silicon, chromium, and aluminum.

28. The method of claim 23, wherein the refractory metal-intermetallic composite article comprises titanium, hafnium, silicon, chromium, and niobium.

29. The method of claim 23, wherein the refractory metal-intermetallic composite article comprises between about 15 atomic percent and about 30 atomic percent titanium, between about 1 atomic percent and about 8 atomic percent hafnium, between about 5 atomic percent and about 25 atomic percent silicon, between about 1 atomic percent and about 14 atomic percent chromium, and a balance of niobium, based upon the total composition.

30. The method of claim 23, wherein the refractory metal-intermetallic composite article comprises between about 15 atomic percent and about 30 atomic percent titanium, between about 1 atomic percent and about 8 atomic percent hafnium, up to about 10 atomic percent tantalum, between about 5 atomic percent and about 25 atomic percent silicon, up to about 6 atomic percent germanium, up to about 12 atomic percent boron, between about 1 atomic percent and about 14 atomic percent chromium, up to about 4 atomic percent iron, up to about 4 atomic percent aluminum, up to about 5 atomic percent tin, up to about 3 atomic percent tungsten, up to about 3 atomic percent molybdenum, and a balance of Niobium, based upon the total composition.

31. The method of claim 23, wherein the refractory metal-intermetallic composite article comprises silicon, germanium, and boron, together comprising between about

5 atomic percent and about 25 atomic percent of the refractory metal-intermetallic composite, iron and chromium, together comprising between about 1 atomic percent and about 18 atomic percent of the refractory metal-intermetallic composite.

32. The method of claim 23, wherein consolidating the powder blend comprises consolidating the powder blend using a technique selected from the group consisting of cold isostatic pressing, hot isostatic pressing, hot pressing, explosive consolidation, magnetic pulse consolidation, ram pre-extrusion consolidation, hot forging, hot swaging, and hot extrusion.

33. The method of claim 23, wherein mechanically deforming the powder blend comprises mechanically deforming the powder blend using a technique selected from the group consisting of cold extrusion, hot extrusion, cold forging, hot forging, cold rolling, hot rolling, cold swaging, and hot swaging.

34. The method of claim 23, wherein the first temperature is less than that required for a silicide reaction to begin.

35. The method of claim 23, wherein the first temperature is less than about 1,050 degrees C.

36. The method of claim 35, wherein the first temperature is maintained for a time of less than about 2 hours.

37. The method of claim 23, wherein the second temperature is greater than that required for a silicide reaction to be complete.

38. The method of claim 23, wherein the second temperature is greater than about 1,050 degrees C.

39. The method of claim 38, wherein the second temperature is maintained for a time of more than about 4 hours.

40. The method of claim 23, wherein the refractory metal-intermetallic composite article has a graded composition.

41. The method of claim 23, further comprising disposing an environmentally-resistant coating on a surface of the refractory metal-intermetallic composite article.

42. The method of claim 23, further comprising disposing a thermal barrier coating on a surface of the refractory metal intermetallic composite article.

43. The method of claim 23, further comprising using high-energy ball milling to achieve a coating of the first powder comprising the refractory metal on the second powder comprising the silicide precursor.

44. A refractory metal-intermetallic composite article manufactured by the method of claim 23.